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NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts,

RALEIGH.

A source of infection.

The Black Rot of the Grape in North Carolina and Its Treatment.

N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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The Director's office is in the Agricultural Building, Raleigh: the experiment grounds and laboratories being at the Agricultural College just west of town and on the street car line.

Visitors will be welcome at all times, and will be given every opportunity to inspect the work of the Station. Bulletins and reports are mailed free to all residents of the State upon application.

Address all communications to

THE AGRICULTURAL EXPERIMENT STATION,
RALEIGH, N. C.

PREFACE.

During the past few years complaints have been numerous and serious regarding the ravages of the "Black Rot" of the grape in the grape growing sections of the State. Large vineyards, particularly of the Niagara variety, were cut down in some sections of the State because of inability to combat the ravages of the rot. As neither the State Department of Agriculture nor the Experiment Station was in position to put an expert in the field to study the disease and make experiments with the view of obtaining methods for overcoming the disease, arrangements were made with the Bureau of Plant Industry of the United States Department of Agriculture, by which the investigations outlined on the following pages were carried out by Mr. A. W. Edson, expert in plant diseases, under the direction of Dr. Albert F. Woods. The expenses of the experiment, outside of salary, were borne jointly by the North Carolina Department of Agriculture and the Experiment Station.

Expression of appreciation is here made of the kindly interest and co-operation of the United States Department of Agriculture in this work, which is of so much importance to this State.

The results are encouraging, and our grape growers will find them of interest and value to their industry.

B. W. Kilgore,
Director.

LETTER OF SUBMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 20, 1903.

Sir:—I have the honor to submit herewith the manuscript of a bulletin on "The Treatment of Black Rot of the Grape," by Mr. A. W. Edson, of this Bureau. The bulletin describes the work which we have been doing in co-operation with the North Carolina Department of Agriculture and the North Carolina Experiment Station, for the purpose of determining the efficacy of spraying as a means of controlling black rot in North Carolina. The experiments were carried on under the direction of Mr. Albert F. Woods, Physiologist and Pathologist, of this Bureau, the funds being supplied by the two State departments above named. Mr. Edson was conducting experiments in North Carolina on other problems, and at the suggestion of the Director of the Station, it was arranged that he should plan and supervise experiments along the lines already pointed out. In view of the fact that the North Carolina Department of Agriculture and Experiment Station furnished the funds for the work, and that the results are particularly applicable to the region in question, I would respectfully recommend that this bulletin be placed in the hands of the Director of the Experiment Station for publication from his office, he having expressed a desire that this arrangement be made, if practicable.

Respectfully,

B. T. Galloway,
Chief of Bureau.

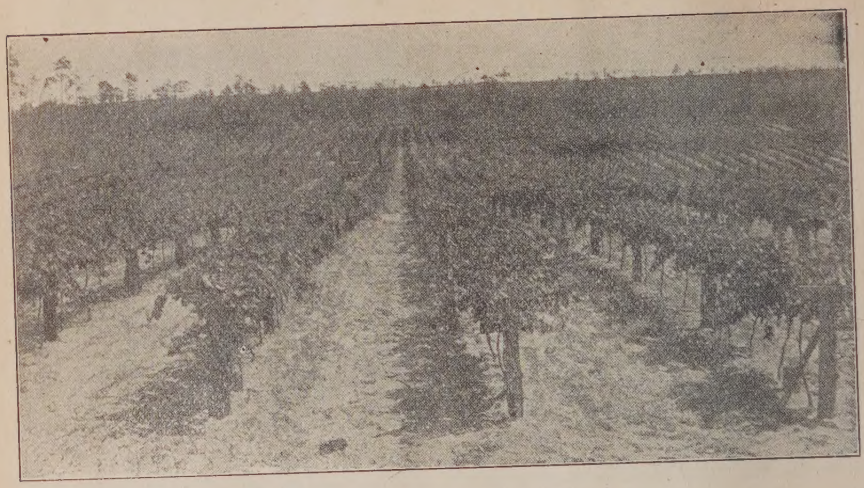
Approved:

Hon. James Wilson,
Secretary of Agriculture.

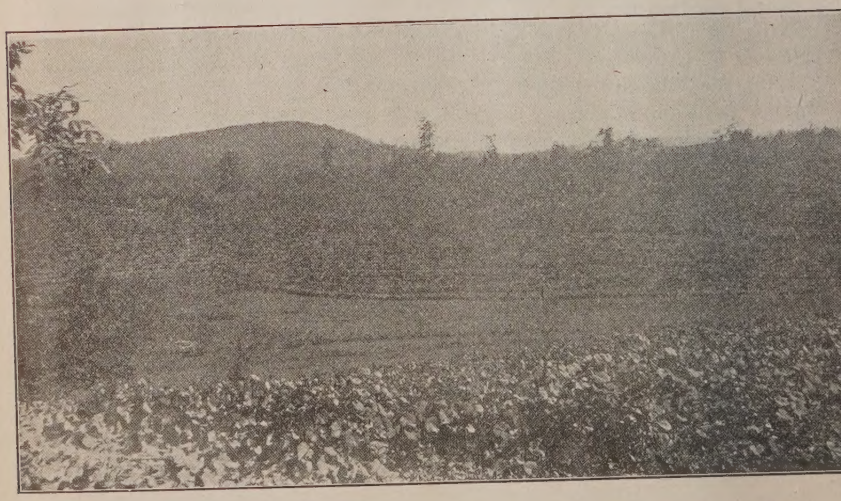
TABLE OF CONTENTS.

PAGE.

Black Rot in 1902 133
Experimental Work 134
Experiments in Spraying Niagaras 136
Plan of Plots and Treatment 136
Applications 136
Applications at Tryon—Table I 137
Applications at Southern Pines—Table II 137
Results of Spraying 138
Weight of Grapes at Second Picking 138
Yields of Rows—Table III 140
Summary of Different Treatments—Table IV 141
Spraying Other Varieties 142
Bagging the Bunches 144
Picking Off Diseased Leaves and Berries 146
Effect of Fertilizers 146
Keeping the Vineyard Clean 148
Making Bordeaux Mixture 148
Ammoniacal Copper Carbonate Solution 152
Application of Boreaux Mixture 152
Cost of Spraying 154



Von Herff Vineyard at Southern Pines, N. C.



Vineyard of Mr. R. F. W. Allston, Tryon, N. C., where experiment plots were located.

The Black Rot of Grapes in North Carolina.

By A. W. EDSON, Bureau of Plant Industry,
U. S. Department of Agriculture.

The black rot, so destructive on both wild and cultivated vines of the Eastern and Southern States, is caused by a fungus, *Guignardia Bidwellii*. This fungus requires for its development, warmth and moisture. The disease appears in distinct waves, of which there are generally two or more in a season, and which are co-incident with, or immediately follow, periods of warm, muggy weather.

The disease first appears on the leaves in small, round spots, about 5 or 6 mm. in diameter, and of an ashy brown. These soon become darker in color and later produce numerous tiny black spore-bearing pustules, about the size of a pin point. These tiny black points are quite visible to the naked eye. Later on the same spots appear on the green berries; probably infection from leaves previously spotted. As on the leaf, these spots are ashy brown at first, then turn darker in color, and put forth the tiny black pustules that bear the spores, the rot then spreading from these spots and destroying the whole berry. Sometimes the entire crop in a vineyard is thus destroyed in an incredibly short space of time. The rotted berries gradually dry up and remain clinging to the vines in a very characteristic manner through the following winter, and even through the spring and summer months. It is from the spores given off from these old dried-up bunches that the infection of the following season is due.

Black Rot in 1902.

During the season of 1902, experiments and observations were made by the Department of Agriculture with a view to the control of the disease. Most of the work was done at Tryon and at Southern Pines, in the State of North Carolina, in co-operation with the North Carolina Department of Agriculture and the North Carolina Experiment Station.

The rot was discovered first at Tryon on the morning of May 14. In the two days preceding there had been frequent showers, followed by periods of hot sunshine with no air stirring. This attack was mostly confined to the leaves on the suckers at the base of the vines. The rot appeared at the same time at Southern Pines, induced, no

doubt, by similar weather conditions. At Tryon there was no material increase beyond what was found the first morning.

The second wave, which likewise appeared both at Tryon and Southern Pines, was less definite in the time of its appearance, and also in its duration. The spell was from May 25 to 30, soon after the grapes were set. Many of the young berries were infected, and considerable damage done.

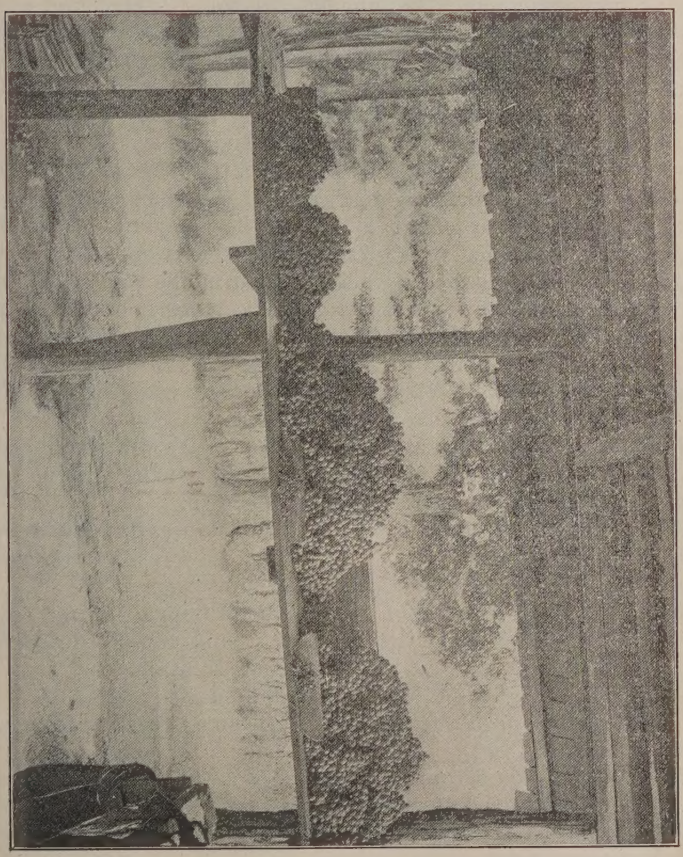
The third wave, which was much the worst, did not appear at Southern Pines. At Tryon, in one vineyard, it appeared as early as June 20. On June 26, 27 and 28 the rot was very destructive; the damage then exceeding that of all the season previous to that time. There were heavy showers during this time, with very hot days. This furnished both the heat and the moisture so favorable to the development of the fungus.

During the season comparatively little rot was found on the Delawares, Brightons, Catawbas, Concords, Cynthianas, or Lindleys. The Gœthes and Salems were rather badly affected, while the Niagaras rotted worst of all.

Experimental Work.

Experiments for the prevention and control of the rot were conducted at both places. Tryon is in the western mountainous region of the State, and is situated in a warm little valley surrounded by mountains, which keep off the cold winds. In this place there are a number of comparatively small vineyards and fruit orchards. The experiments were conducted in the vineyard of Mr. R. F. W. Allston. The Niagara was the main variety grown here, but there were also small blocks of Delawares, Catawbas, Lindleys and Brightons. The rot had been especially destructive the two preceding seasons. The vineyard was plainly badly infected, the old rotten bunches visible everywhere lying on the ground and hanging to the vines. Two blocks, each surrounded by untreated vines, were reserved for the experimental work here.

Southern Pines, the other station, is in the central part of the State, in the long-leaf pine belt. The vineyards here are much larger than at Tryon, some of them frequently sending out a car load of grapes a day to the larger Northern cities. The experiments were carried on in the vineyard of Dr. B. von Herff. Only two varieties were grown, the Niagara at one end and the Delawares at the other. The rot had been so destructive in the Niagara section that cultivation had been given up. The vines were merely cut back, leaving the old tops on the trellises with the shrivelled, rotten berries clinging to them. In the very middle, surrounded on all sides by these neglected vines, a block of 800 vines were pruned and cultivated as usual to be used for the spraying experiments.



On right Grapes from Sprayed Row, 6-4-50 formula. In the middle Grapes from Sprayed Row, 12-8-60 formula. On left, Grapes from Unsprayed Row. Good Grapes at back. Poor Grapes in front.

Experiments in Spraying Niagaras.

PLAN OF PLOTS AND TREATMENT.

The spray treatments were the main experiments of the season. There were four plots of these, all exactly alike. Each plot contained eight rows of about twenty vines each. Each row received a somewhat different treatment, as indicated below. At the end of each plot a solid block of a quarter to half an acre (depending on length of rows and shape of vineyard), was sprayed through the season with normal (6-4-50) Bordeaux mixture, in order to have spraying on a large scale for further observation.

Plots *a* and *b* were at Tryon in the Allston vineyard. Plot *a* was at the top of one of the hill sides on which the vineyard was situated, and at nearly the highest point. Most of the vines were of uniform size and in as good condition as any in the vineyard. The vines in this vineyard were not in a very vigorous condition. Plot *b* was in another part of the vineyard and situated at the foot of one of the hillsides at nearly the lowest point. The vines in this were not so uniform, many of them being in very poor condition, and setting very little fruit. It is not fair to include these rows in the general result, so rows 3, 4 and 5 were left out in the general averaging up. Row 2 was considerably better than the other rows.

Plots *c* and *d* were situated side by side in the von Herff vineyard at Southern Pines. The vines were trained after the Munson system, and were particularly uniform and well grown.

The plan and treatment of all the four plots was as follows:

Row 1, unsprayed.

Row 2, Bordeaux 6-4-50 formula, all sprayings.

Row 3, Bordeaux 12-8-50 formula, all sprayings.

Row 4, first two sprayings omitted, second two Bordeaux 6-4-50 formula, last two 1 per cent copper sulphate solution.

Row 5, Bordeaux 6-4-50 formula, and bunches bagged.

Row 6, Bordeaux first sprayings, Bordeaux Lysol last three sprayings.

Row 7, Bordeaux 6-4-50 formula, first four sprayings; ammoniacal copper carbonate (*b*) last two sprayings.

Row 8, Bordeaux 6-4-50 formula first three sprayings, Lysol solution last sprayings.

Applications.

Six applications were made in all. At Tryon the first application copper sulphate solution, six pounds to the barrel, was made March 31, while the vines were still in a dormant condition. The second application was made May 10-11, immediately before the blossoms

a. United States Department of Agriculture, Farmers' Bulletin, No. 38, p. 5.
b. United States Department of Agriculture, Farmers' Bulletin, No. 38, p 8.

opened. This should have been made at least a week earlier, but delay in getting the apparatus in working order prevented. The first wave of black rot appeared only two days later. The third spraying was May 19-20, after the blossoming time was over; the fourth on June 3-4; the fifth, June 19-20; the sixth and last, June 28-30. The same applications were made on corresponding dates at Southern Pines. The dates of the applications and the materials used on each row at each date are here given in tabular form. All spraying at both places was under the direct personal supervision of the writer.

TABLE I.

Showing Applications Given Each Row on Each of the Six Dates.

Plots *a* and *b* at Tryon.

	March 31	May 10-11	May 19-20	June 2-3	June 19-20	June 28-30
1. Unsprayed						
2. Bordeaux 6-4-50 formula	CuSO4	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50
3. Bordeaux 12-8-50 formula	CuSO4	12-8-50	12-8-50	12-8-50	12-8-50	12-8-50
4 Two omitted, two Bordeaux, two CuSO4			6-4-50	6-4-50	{ 1 per ct. CuSO4	1 per ct. CuSO4
5. Bagged	CuSO4	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50
6. Bordeaux-Lysol	CuSO4	6-4-50	6-4-50	{ ½ per ct. Lysol. 6-4-50	{ ¼ per ct. Lysol 6-4-50	{ ⅛ pr. ct Lysol, 6-4-50
7. Bordeaux, last two Ammoniacal	CuSO4	6-4-50	6-4-50	6-4-50	Ammoniacal	Ammoniacal
8. Lysol	CuSO4	6-4-50	6-4-50	1 per ct. Lysol.	1 per ct. Lysol.	

Plots *c* and *d* at Southern Pines.

	April 4	April 28	May 23	May 30	June 13-14	July 3
1. Check						
2. Bordeaux, 6-4-50 formula	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50
3. Bordeaux, 12-8-50 formula	12-8-50	12-8-50	12-8-50	12-8-50	12-8-50	12-8-50
4. Two omitted, two Bordeaux, two CuSO4			6-4-50	6-4-50	{ 1 per ct. CuSO4	{ 1 per ct CuSO4
5. Bagged	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50	6-4-50
6. Bordeaux-Lysol	6-4-50	6-4-50	6-4-50	{ ½ per ct. Lysol 6-4-50	{ ¼ per ct. Lysol 6-4-50	{ ⅛ pr. ct Lysol 6-4-50
7. Four Bordeaux, last two Ammoniacal	6-4-50	6-4-50	6-4-50	6-4-50	Ammoniacal	Ammoniacal
8. Lysol	6-4-50	6-4-50	6-4-50	1 per ct. Lysol	1 per ct. Lysol	

At both places a barrel sprayer conveniently mounted on two wheels was used. At Tryon, one man did the pumping and another handled the nozzles, the spray cart going up one side of the row and coming back on the other. This insured all the rows and both sides of each row being sprayed very nearly alike. At Southern Pines the vines were larger and trained in the Munson system, and after the vines were fully branched out, one man standing on the ground could not spray the broad spreading tops of the vines. In the last three sprayings, therefore, one man walked on the ground and sprayed the under side, while another rode on the cart and sprayed the upper side of the vines. Both sides of each row were sprayed in the same way. At Tryon, the vines being smaller and trained in the Kniffen four-arm system, this extra man was not needed. In all cases Vermorel nozzles with very fine caps were used.

For the first application before the leaves appeared, single Vermorel nozzles were used. At the second and third sprayings, double nozzles were used. For the others, extensions carrying three nozzles were used. At the fourth application, a double nozzle was used in the middle, and single ones at each end, making four nozzles in all. At the fifth and sixth sprayings, three double nozzles were used. By means of this extension carrying three nozzles, a broad sweep of fine spray was obtained, which covered the vines quite rapidly and thoroughly.

The Results of Spraying.

At Southern Pines, in my absence, the grapes from the experimental plots, owing to an unfortunate mistake, were picked the first time without being weighed or measured. The second picking was weighed, and the weights from each row are given below. There was probably not so great a difference as the figures of this second picking would indicate, since the rows yielding the most did not mature their fruit as early as those with a smaller yield. In these plots there were twenty vines in each row, and all the vines were uniform.

Weight of Grapes at Second Picking.

	Plot *c*.	Plot *d*.	Average.
Row 1, Unsprayed	7	17	12
Row 2, Bordeaux 6-4-50	55	48½	51¾
Row 3, Bordeaux 12-8-50	52	54½	53¼
Row 4, Two omitted, two Bordeaux, two Ammoniacal	53½	70	61¾
Row 5, Bagged	122	104½	113¼
Row 6, Bordeaux-Lysol	57½	77½	67½
Row 7, Four Bordeaux, two Ammoniacal	54½	82	68¼
Row 8, Three Bordeaux, two Lysol	66	46	55

Grapes from sprayed row on left. Grapes from unsprayed row on right.

The grapes from the plots at Tryon were picked August 8-15. The bunches from each separate vine in each row were picked, counted, weighed, trimmed and weighed again. The averages of the numbers and amounts obtained in each row are given in Table III. In nearly every row there were some vines that set only a few bunches, or even none at all. These were noted and omitted in computing the averages for the row.

TABLE III.

Showing Yields of Rows in Plots *a* and *b*.

	Number of Vines in Row.	Number of Vines Taken.	Total Number of Bunches.	Average Number to Vine.	Total Weight Picked.	Total Weight Good.	Total Waste.	Average Weight Good.	Average Waste.
					lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
1—a	19	17	385	22.6	22— 6	14— 6	8— 0	0 13.5	0—7.5
2—a	18	17	402	23.6	78— 9	77— 0	1— 9	4 - 8.0	0—1.5
3—a	18	17	435	25.6	82—11	80—14	1—13	4—12.0	0—1.7
4—a	18	13	266	10.5	45—11	42—11	3— 0	3— 5.0	0—3.7
5—a	19	13	288	22.2	52—15	49 - 13	3— 2	3—13.0	0—3.8
6—a	21	16	385	24.1	75— 2	72— 8	2—10	4— 8.5	0—2.6
7—a	22	17	392	23.0	74—13	73— 0	1—13	4— 5.0	0 -1.7
8—a	25	13	230	17.7	35—15	33—12	2— 2	2— 9.5	0—2.6
1—b	19	15	332	22.1	25— 0	20— 3	4—13	1— 5.5	0 -4.8
2—b	19	16	435	27.2	69—11	67—11	2— 0	4— 3.7	0—2.0
3—b	20	20	357	17.8	59— 6	57— 7	1—15	2—14.0	0—1.9
4—b	20	20	345	17.3	40— 2	37— 6	2—12	1—13.9	0—2.2
5—b	19	10	168	16.8	29 - 7	28— 7	1— 0	2—13.5	0—1.6
6—b	21	19	367	19.3	61—12	60— 6	1— 6	3— 2.8	0—1.2
7—b	20	15	283	18.8	46— 8	45— 3	1— 5	3— 0	0—1.1
8—b	20	20	415	21.0	53 -13	49— 5	4— 8	2— 7.4	0—3.6

In Table IV, the results in plots *a* and *b* are averaged and summarized. In making up this summary, rows 3-b, 4-b and 5-b were omitted, as all the vines in those rows were much below the average in vigor and productiveness.

TABLE IV.

Summarizing Results of Different Treatments.

	Number of Vines.	Average Number of Bunches.	Average Weight. Good.	Average Weight Waste.
			lb. oz.	lb. oz.
1. Unsprayed	32	22.3	1— 1.5	0-6.1
2. Bordeaux 6-4-50	33	25.4	4— 5.8	0-1.7
3. Bordeaux 12-8-50	17	21.7	4-12.0	0—1.7
4. Two omitted, two Bordeaux, two $CuSO_4$	13	10.5	3— 5.0	0—3.7
5. Bagged	13	19.5	3—13.0	0—3.8
6. Bordeaux-Lysol	35	21.7	3—13.6	0—1.9
7. Bordeaux; last two Ammoniacal	32	20.9	3—10.5	0—1.4
8. Lysol	33	19.3	2— 8.4	0—2.7

As seen above, the average weight of good grapes obtained from a vine in the unsprayed rows was 1 pound 1.5 ounces, as compared to 4 pounds 5.8 ounces from those given six sprayings with normal Bordeaux mixture, a difference of 4 pounds 4.3 ounces to the vine, or over a ton to the acre. This gain of a ton or more of grapes to the acre was due entirely to the six sprayings, at a cost of about $15.42. In addition to this increased yield, the grapes could be picked at less cost, the trimming could be almost done away with, and in the end a product of far better quality commanding a higher price was obtained.

The yield from the rows sprayed with the double strength Bordeaux (12-8-50 formula) was very little more than the rows sprayed with the normal mixture.* However, the vines were healthier looking and there was less black rot on the leaves and berries, hence the stronger mixture must be considered the most effective. Ordinarily, the 6-4-50 formula is strong enough, but in a wet season or during spells of hot, wet, muggy weather, when black rot infection is more likely to take place, I should recommend the use of a stronger mixture, one containing 8 or 9 pounds of sulphate and the corresponding amount of lime to the barrel.

The first two sprayings were omitted from the fourth row; in consequence, the yield was not quite so high as in the neighboring row sprayed the six times. To avoid the stains made by Bordeaux, a 1 per cent solution of copper sulphate was used for the last two sprayings, and while this point was attained the foliage was otherwise injured to some extent. As there was no black rot after these sprayings were made, no evidence was obtained as to the effectiveness of this solution in preventing rot.

* United States Department of Agriculture, Farmers' Bulletin, No. 38, p. 5.

Bags were used in the fifth row. This method is discussed on page 144. The sixth row was sprayed with normal Bordeaux mixture. In the 4th, 5th and 6th sprayings $\frac{1}{2}$, $\frac{1}{4}$ and $\frac{1}{8}$ per cent respectively of lysol was added to the Bordeaux. This had the effect of making the spray spread over the berries better. That this row did not yield as much as rows 2 and 3 was due rather to the fewer bunches set than to the differences in spray treatments.

On the last two sprayings ammoniacal copper carbonate solution was used in the place of the Bordeaux mixture in order to avoid the Bordeaux stains. The solution was satisfactory in this respect and did not injure the foliage. Its effectiveness as compared with Bordeaux for the prevention of black rot was not learned since there were no attacks of black rot after these applications. The probability, however, is that this is the best solution to use for the last sprayings.

The eighth and last row was sprayed with Bordeaux at first and with lysol on the fourth and fifth sprayings. Lysol is an antiseptic prepared from cereosol, which was used and recommended several years ago by some French vineyardists as a protection against black rot and claimed to be more effective and satisfactory than Bordeaux for that purpose. A 1 per cent solution of lysol was used for the fourth spraying. When thoroughly agitated the preparation somewhat resembles soap-suds. The application was made in the afternoon, the day being bright and clear. A few days later some injury to the leaves was noticed. Accordingly, at the fifth spraying a solution of only $\frac{1}{2}$ per cent was used. This application was made on a cloudy morning immediately after the dew was off. The next day the leaves were found to be very badly damaged, probably because the stomata were more open in the cloudy weather. The injury was so great that at the time of the sixth spraying another row was used and a $\frac{1}{4}$ per cent solution applied, with no bad effects. Notwithstanding the two applications of lysol there was more rot on these two rows than on any of the other rows receiving treatment, while in addition to injuring the leaves the lysol specked the berries, very much injuring their appearance. From all this it appears that lysol can not safely be used and does not prevent the rot, even when used in strengths injurious to the vine. Also, it is more expensive than Bordeaux.

Spraying Other Varieties.

Besides the spraying on the Niagaras, small blocks of Delawares, Catawbas, Lindleys and Brightons were sprayed five times with normal Bordeaux mixture. No rot or other fungus disease was seen on these sprayed vines during the season. The greatest injury among the unsprayed vines of these varieties was caused by mildew, many vines being completely defoliated before the fruit had ripened.

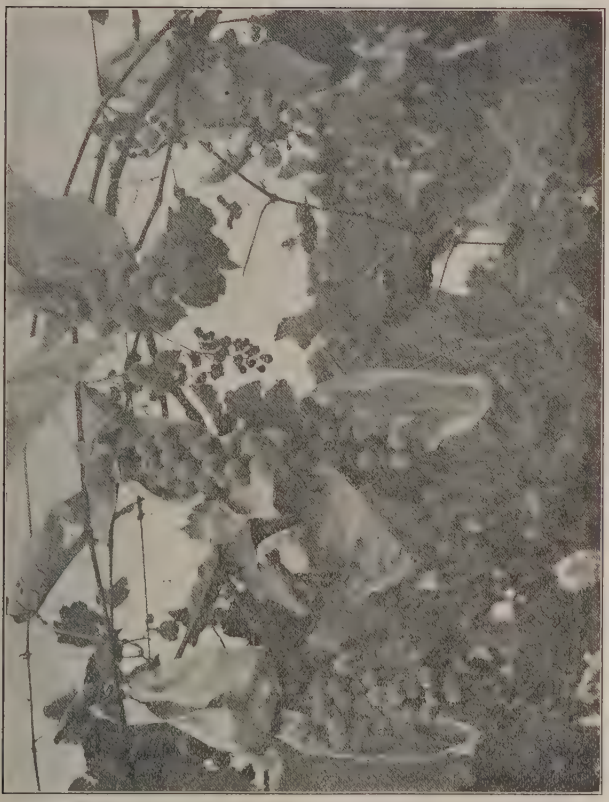
Bagged bunches on vines at Southern Pines.

These four varieties were plainly much less susceptible to rot than the Niagaras. This suggests that some other large white varieties might perhaps be substituted for the Niagara.

Bagging the Bunches.

One row in each of the four plots was bagged for comparison with the spraying methods. Three-pound bags were fastened by means of pins or pieces of wire, over the bunches, just after they had set. In the bagged rows the average yield of good grapes to the vine was 3 pounds 13 ounces, or about 9 ounces less than that in the sprayed rows.

The bunches on both the sprayed and unsprayed rows were bagged at different dates, beginning when the grapes were in full bloom. When the grapes were picked no difference could be detected in favor of those sprayed before bagging. Bagging seemed to prevent further rot, even in bunches where it had already begun. Neither did the time of bagging make any difference after the grapes had fully set, but those bagged when in full bloom had small berries and imperfect bunches. It is recommended, however, that bagging be done as soon as possible after the bunches have set. The cost of bagging is somewhat more than spraying. The bags in quantity cost a little less than $1.00 a thousand, and an ordinary hand should put on one thousand bags a day. By using cheap labor at an average of 75 cents a day, the cost of one thousand bags put on the vines would be about $1.75, accordingly one may estimate the cost of bagging the best bunches on an acre of vines at about $18.00. The bagging can be done all at once in the early part of the season and does not have to be repeated at intervals. Very cheap labor can be used and do just as good work as better labor. The grapes when picked are cleaner and better looking than grapes that have suffered from exposure to the weather and insects. On the other hand, many of the smaller bunches that may be saved by spraying, it does not pay to bag, and it is impossible to bag some of the larger bunches, owing to their position on the trellises or among the vines, while some of the bags are blown off during storms. So after all, quite a proportion of the grapes remain unprotected by the bagging method. Bagging does not protect the leaves from rot, mildew and other fungus diseases, as is done by Bordeaux, but it is a fairly satisfactory method of protecting grapes from black rot and may be recommended to those who are unable to do good work in spraying. Spraying is the best and cheapest method, if it is done properly, as, in addition to protecting the grapes, it is of considerable value in keeping up the general health and vigor of the vines.



Bags torn away at end of season, showing the bunches free from rot. Bunches unbagged partly or entirely diseased.

Picking off Diseased Leaves and Berries.

At Tryon experiments were made in picking off diseased leaves and berries, both from sprayed and unsprayed rows. The unsprayed rows, being completely surrounded by infected and neglected vines, were constantly re-infected so that the diseased berries and leaves soon became too numerous to handle. This method might succeed in a vineyard nearly free from rot, but certainly could not succeed in a badly-infected vineyard. In the sprayed rows only a few pickings were required and these took but a short time. In all the rows picked the average number of diseased leaves to the vine was less than one in the sprayed rows and was over eleven in the unsprayed rows. The leaves from the sprayed rows generally had but one or two spots while those from the unsprayed rows were frequently covered with spots. Where spraying has been carefully done it is perfectly possible and seems desirable to pick off the few leaves and berries that may have been missed and become diseased, as each spot may become a source of infection to newly developed tissues or to parts not thoroughly sprayed. As each rotten berry must in any case be removed before the bunches are packed it is better to take it out when the bunch is still growing so that the empty space may be filled in by the other berries, thus making a more compact and finer looking bunch. It is better and cheaper and a finer product is obtained if this trimming is done as soon as the spots appear, than if one waits for greater damage to be done.

The Effect of Fertilizers.

It has been suggested that the use of fertilizers, especially of nitrogenous fertilizers, tended to make the grapes more liable to rot. At the Experimental Farm of the North Carolina Horticultural Society there are plots of grapes, peaches and other fruits receiving different fertilizer treatments. Capt. McNair, the superintendent, stated that in 1901 the amount of nitrogen used had a very marked effect upon the amount of brown rot occurring in the peach plots; the more nitrogen used, the more rot. In these plots under treatment a part of each row was fertilized and a part left unfertilized. I kept watch of these as well as the grape plots in the different fertilizer trials, but there was not enough rot in either place to permit one to arrive at any definite conclusions in regard to grapes. However, I noticed that in some places where grapes were in poor soil and poorly fed the vines were less vigorous and much more susceptible to rot. It would therefore seem that the vine should have enough of the different fertilizer elements to keep it in a healthy, thrifty condition. It is possible that more nitrogen than is actually needed by plants may make grapes as well as peaches liable to rot.

Average sprayed bunches from sprayed plots at Tryon, 6-4-50 formula.

Keeping the Vineyard Clean.

No experiments were made in this line, but a number of different vineyards were under observation. In those vineyards where all of the old dead leaves and rotten grapes had been carefully cleared away and the prunings burned the previous fall, there was very little rot after the spraying of the following season. My own experiments in spraying Niagaras in the midst of badly infected vines show that, at least in an ordinarily good season, it is possible to almost entirely prevent rot by spraying alone. In most cases, however, among the Niagaras where the vineyard was not cleaned there was more or less rot. In those Niagara vineyards that were neither cleaned nor sprayed, the rot was generally quite destructive.

Bordeaux is not a cure, but a preventive. In a good season, and perhaps in any season, thorough spraying would be sufficient without the cleaning up. It is during critical periods of bad weather that black rot gets a foothold and spreads and destroys the crop. If, at such a critical time, the Bordeaux has just been applied and covers every part of the vine, all may be well, but if not, infection may take place, more especially if there are diseased leaves and rotten grapes lying around on the ground and clinging to the vines. At such a time it would be advantageous to have the vineyard as clean as possible, especially where the Niagara is grown. Accordingly, it is recommended that all dead leaves and rotten grapes be raked up and removed, and rotten grapes clinging to the vines and trellises picked off. Loose, shredded bark that can be readily pulled from the vines, prunings, dead grass and weed should be burned; in fact, anything capable of harboring the dust-like spores should be destroyed or taken away. While the vines are still in a dormant condition, spray with the copper sulphate solution, thoroughly wetting the vines and posts, and paying particular attention to bunches of tendrils or rough surfaces on the posts that would be likely to retain the spores. Keep the whole surface of the ground cultivated in order to bury such spores as have lodged on the surface. Then spray. It is much easier to keep black rot out of a vineyard once cleaned, than to keep it down in a vineyard not cleaned.

Making Bordeaux Mixture*

Many of the failures in the use of Bordeaux mixture are due to the fact that it has not been properly made. Improperly made, Bordeaux mixture is likely to settle even before it can be applied, so that a part of the vines sprayed from the barrel do not receive their full amount of copper. Such Bordeaux does not stay on well. After paying for the materials and going to the trouble and expense of making the applications, vine growers, through ignorance or carelessness

* United States Department of Agriculture Farmers' Bulletin, No. 38, pp. 5-8.

Average yield from sprayed vine on left; average yield from unsprayed vine on right.

in preparing the Bordeaux, often lose the whole benefit of their spraying.

Bordeaux mixture consists of six pounds of copper sulphate and four pounds of lime in a barrel of water. The lime and the copper sulphate are generally kept in stock solutions of one pound to a gallon of water. In making this solution of the sulphate, it is only necessary to measure out the water in a clean barrel, and having weighed out the required amount of sulphate, tie it up in a square of cheese cloth and suspend near the surface of the water.

It is more difficult to get a good lime solution. The best quicklime should be obtained. After weighing, it should be placed in the bottom of a clean barrel and slacked there by pouring over it at first a small quantity of warm water until the slacking begins, then gradually adding more water as the process continues. When all the lime is thoroughly slacked, the water to the required amount can be added, and the whole thoroughly mixed by stirring. The lime solution should always be thoroughly stirred before any is taken out to make the Bordeaux.

In making up the Bordeaux mixture, the two stock solutions should never be poured together, but both should be considerably diluted before mixing. The lime should be strained through a strainer made of brass netting, having about twelve meshes to the inch. If one dilute solution is poured into the other, *it should be always the sulphate solution that is poured into the lime solution, never the reverse;* and the mixture meantime should be kept thoroughly agitated by stirring. This pouring should be rather slow, in order to give time for the chemical reactions while the two solutions are in a state of agitation.

In making up Bordeaux, the writer employed a method suggested by Mr. M. B. Waite, of the Department of Agriculture, and found it very satisfactory. A rough platform was built on a side hill, on which were the barrels containing the stock solutions of lime and sulphate, and two half barrels having short pieces of garden hose attached to the bottoms. To make the Bordeaux, a stock solution of four pounds of lime was put into one half barrel and the solution of six pounds of sulphate in the other, and both were filled up with water by means of a hose. The spray cart was then backed up at the lower side of the platform and the two dilute mixtures run out through the strainer into the pump barrel through the pieces of hose. By this means the lime and sulphate are diluted, are thoroughly mixed while being run into the barrel, and are not combined too rapidly to make a good mixture. Under these conditions a light flocculent precipitate is formed that will not settle readily. If the solutions are too concentrated when brought together, or are not sufficiently mixed, the precipitate is coarser and heavier, and is likely to settle within a few minutes, with the bad results already described.

Average bunches from unsprayed plots at Tryon.

Unless for very good reasons, the proportion of lime to sulphate given in the directions should be used. If less than four pounds of lime to six pounds of sulphate is used, the foliage is likely to be burned. The general tendency, however, is to use more lime. This is undesirable for three reasons. It is the lime particles that are likely to clog the nozzles, so the more lime used the more liable the nozzles are to clogging, if nozzles are used with holes as fine as they should be. Secondly, from general observations I have concluded that the more lime used, the more easily the mixture is washed off. Thirdly, it is the sulphate that is effective in killing the spores and preventing the black rot. The lime is added simply to counteract sufficiently the poisonous action of the sulphate, so that it will not also injure the grape foliage. The aim in making Bordeaux is to make the sulphate as destructive as possible to the fungus without also being injurious to the leaves of the plants. If more lime is added than is necessary for this purpose, the toxic action of the sulphate may be so far weakened that it will not kill all the fungus spores, and the rot may follow.

Ammoniacal Copper Carbonate Solution.*

To make this preparation, dilute three pints of ammonia with six pints of water. Use enough of the solution to dissolve five ounces of copper carbonate. The resulting solution, diluted with water, will make one barrel of spraying fluid. If they have previously been used for Bordeaux, the pump barrel and other receptacles should be cleaned before being used for the ammoniacal solution, since the lime deposited by the Bordeaux is likely to combine with the solution and form a precipitate that would stain the grapes.

The Application of Bordeaux Mixture.†

Wherever possible, a good barrel pump should be used. With this one man can do the pumping and a man on each side of the spray cart can spray thoroughly and rapidly the side of the row against which he walks. The spray is driven in against the foliage with considerable force, and is quite well distributed. With such an apparatus there is not so much temptation to slight the work in order to get over the ground more rapidly.

The part of the apparatus most generally at fault is the nozzles, which are almost without exception too coarse. None but the Vermorel type should be used, and these should have caps with holes not larger than a No. 2 needle. Such nozzles throw a fine, mist-like spray that is deposited in very fine particles that cover nearly or quite the whole surface of the leaves and berries. The coarser nozzles throw the spray in streams or fine drops that strike the leaves and roll off,

*United States Department of Agriculture Farmers' Bulletin, No. 38, p. 8.
†United States Department of Agriculture Farmers' Bulletin, No. 38, pp. 8-10.

Sprayed vine on left, unsprayed on right.

or collect, leaving the Bordeaux in blotches or spatters. The fine nozzles spread the mixture more uniformly, make it stay on better, and are more economical of material.

After the grape vines are in full leaf, an ordinary single or double Vermorel nozzle of the requisite fineness will not be sufficient to spray the vine well without stopping some little time at each vine. An extension carrying three nozzles will then be found to be a convenient and time-saving device. Such an extension rod can be made from 3-8 inch pipe by any plumber, at a cost of fifty or seventy-five cents Then either single or double Vermorels, as preferred, can be attached to this. Such a device gives a broad sweep of finely-divided spray that covers the vines rapidly and effectively. With a sufficient number of nozzles and a slow-going horse, the spray rig can be kept moving almost continuously and still do good work.

Every application should be thorough. The spray should be directed into the vine from both above and below, and from each side of the trellis, so far as possible to cover every leaf on both sides. Care should be taken to strike the woolly under surface of the leaves, as this is especially adapted to catch and retain the spores of the black rot fungus.

The first spraying should be with copper sulphate solution (6 lbs. of sulphate to a barrel of water), and applied while the vine is still dormant. Posts and wires as well as vines should be thoroughly treated. The second spraying should be made after the leaves and fruit buds have appeared, but before the flowers open. The third application should be made after the blossoming time, when the fruit has been set about ten days or two weeks. The other sprayings should follow at intervals of ten days until the first or middle of July. At the end of ten days so many new and tender leaves have developed, and the small berries have so increased in size, that it is dangerous to leave them unprotected for a longer time. After the vine is well grown, it is impossible, if the growth has been vigorous, to reach all the foliage with the spray. But if sprayed at intervals of ten days the whole vine will be reached from within outward as it develops.

Cost of Spraying.

At Southern Pines a careful account was kept each time of the number of vines sprayed with Bordeaux, the amount of mixture used, and the time required for the applications. These figures gave the estimate cost per acre of both material and labor. The Bordeaux costs almost exactly fifty cents a barrel The labor is estimated as the work of three men, each at $1.00 per day, one for the pumping and two to do the spraying; but in the majority of cases it would be sufficient for one man to spray, taking one side of a row at a time; this would considerably lessen the cost of labor. Probably, too, the

expense of experimental treatment on this small plot was proportionately more than for work on a larger scale.

The following table gives the cost of the material and labor per acre for each of the six sprayings:

	Amount Per Vine.	Cost of Material.	Cost of Labor.	Total Cost Per Acre.
1st	1½ gallon.	$0.45	$1.13	$1.58
2nd	1-8 gallon.	.68	1.13	1.81
3rd	1-7 gallon.	.68	1.10	1.88
4th	1-4 gallon.	1.36	1.47	2.83
5th	2-5 gallon.	2.06	1.65	3.71
6th	2-5 gallon.	2.06	1.65	3.71
Total		7.39	8.13	15.52

The seasons of 1900 and 1901 were unusually bad seasons in succession, and were very discouraging to the grape growers of North Carolina. The black rot made a nearly clean sweep, especially in the Niagara vineyards. Similar seasons can not, however, be expected to occur very often. At the close of the season of 1901, many growers had lost faith in the efficacy of Bordeaux as a preventive of black rot. But in the month of June there were rains nearly every day; there was scarcely time to get the Bordeaux on between rains, and not time enough for it to dry enough to stay on, even if the applications were made. At the same time conditions were extraordinarily favorable for the development of the black rot fungus. The previous bad season had stocked the vineyards well with the fungus. Under such conditions it was not strange that there was an unusual development of rot.

The season of 1902 has been a good one. These experiments, as well as the experience of many of the grape growers, have shown that in such a season, at least, grapes, even the susceptible Niagara, can be grown in North Carolina in spite of the black rot. And this, too, after the vineyards were badly infected by two seasons of black rot. In some cases good grapes from the less susceptible Delaware were grown without spraying. All this is encouraging. Not all the seasons are going to be bad seasons. I am confident that by clean cultivation and careful spraying any variety of American grapes can be grown in most years if not in all.

The treatment recommended can be summarized as follows:

1. Clean up all old leaves, rotten grapes and other rubbish in the vineyards. Cultivate the ground so as to cover such material as can not be cleaned up.

2. Keep the vines in healthy, vigorous condition by cultivation and by the application of such fertilizers as are needed.

3. Spray thoroughly at least six times during the season according to directions, using the 6-4-50 formula generally, but increasing the strength in hot, muggy or wet weather.

4. Be very careful in making the Bordeaux mixture.

5. Use finer nozzles.

6. Beside spraying, when practicable pick off diseased leaves and berries.

7. When black rot appears in the vineyard, do not, for the sake of cutting down the expenses, neglect the vines. That is just when the vineyard needs more care. Those who spray for the first time in badly infected vineyards, must be much more thorough in making the full number of applications, and in doing this work carefully, than would be necessary in vineyards nearly free from rot. Only by such careful and thorough work can the black rot be kept down.